

REMARKS

The Examiner has deemed the last Amendment and Response of November 21, 2002 to be non-responsive in failing to clearly point out how the claims distinguish over the references applied in the Office Action (Paper 14), namely U.S. Pat. Nos. 5,833,846 (*Tanabe*), 4,863,608 (*Kawai*), 4,676,908 (*Cipriela*), 5,118,422 (*Cooper*) and the Japanese Patent Applications 61101292 and 53149873. The claims are distinguished as follows:

The present invention is directed to methods of treatment for producing ultrapure water, such as ultrapure makeup water for power plants and ultrapure water for semiconductor fabrication plants. In particular, it is directed to methods and devices for removing substantially all inorganic and organic carbon compounds from such waters.

In raw waters or slightly-processed municipal waters, carbon compounds are almost always present (*see*, claims 1 and 12). They can include dissolved carbon dioxide gas, mineral carbonates and many residues or products from organisms. A number of these (such as small soluble organic acids) are readily removed by certain ion exchange or deionization units, while others (such as certain hydrocarbons) may be relatively unaffected by those treatment units, but can be captured by activated carbon, or converted by strong oxidizers to more treatable forms. Typically, activated carbon may introduce further contaminants, particularly particulates, that require the use of additional downstream treatment modalities; similarly, the use of strong oxidizers may require careful consideration of compatible processes to avoid treatment complications.

One common construction that should be held in mind as general background is that the final loop of a semiconductor fabrication water treatment plant generally operates with a loop in which the product water from the primary make-up line goes to a deionized water tank (such as tank 107 of U.S. Patent 5,833,846 of *Tanabe et al.*), and the tank water is circulated through a UV unit, cartridge polisher and a membrane separator on a continuous basis to scavenge bio-growth organic products from the water. The UV serves both as a biocide to kill any organisms that may colonize the water system, and as an oxidizer to break down carbon compounds to a form that will be captured by the ion exchange resins in the cartridge polisher.

Another common construction is the placement of an oxidizer or UV treatment ahead of some treatment unit generally (such as reverse osmosis, electrodeionization) where the UV

attacks some component of the feed water and renders it at least partly removable, or converts it at least partly to a form that is non-fouling for the downstream process unit.

However, in a ultrapure water (UPW) plant, the level of carbon contaminants is already quite low, as major scale-forming carbonate species and gas will generally be removed early. Since the effect of UV is largely dependent on absorption, which will decrease at low concentration, there is a limit to the efficacy of UV oxidation in treating such waters. It has been proposed to address this inefficiency by employing the UV in a photocatalytic, not simply photolytic, process. Thus, the *Cooper '422* reference shows the use of semiconductive metal oxide powders to increase the level of UV-mediated breakdown, by surface capture and catalysis followed by separation of the water from a recirculating powder-bearing treatment loop. The *Kawai '608* reference shows another photocatalytic process to address the low efficiency of UV treatment of low-total organic carbon (TOC) waters.

However, even if the efficiency of UV-mediated reaction is increased, a second potential problem remains. As described in the specification, on page 5, lines 6-15, while irradiation with UV may convert non-ionized organic matter into ionic or ionizable species, UV may also convert ionic and/or ionizable organic species into non-ionizable organic species. The result of this is that if a significant portion or amount of the organic species are in ionic and/or ionizable form, application of the UV may actually increase the concentration of non-ionizable organic matter (hence, not removable by electrodeionization (EDI)) and treatment by EDI or reverse osmosis (RO) would then produce a lower reduction of TOC (*i.e.*, more remaining TOC) than would have occurred without the UV. Furthermore, the ionic and ionizable organics, which don't need any UV breakdown, will compete for UV photons, absorbing some available UV and reducing the UV available for converting non-ionizable organic matter into ionic or ionizable species.

Perhaps the closest art cited by the Examiner is the Japanese patent reference 61101292, * ✕ which shows a first UV unit 11a ahead of a first ion exchange bed 12a, with the product passing to a second UV unit 11b ahead of a second ion exchange bed 12b. While Applicant neither possesses the complete patent nor a translation, the Abstract identifies the purpose of that construction as being to save power consumption by connecting a number of units in series, or treating plural times to perfectly remove the organic substances. It does not appear to address the problem identified by Applicant that in low TOC ultrapure water, conversion of ionizable species

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to non-ionizable species and UV absorption by ionizable species impair the effectiveness of UV treatment and may produce unexpected increases. There is no indication of any such awareness in the 1986 Japanese treatment process, and the language of claim 1 is believed to clearly distinguish thereover.

The other Japanese patent publication is more remote, in that it simply involves a single UV unit between an RO and an ion exchange unit, and is thus somewhat similar to U.S. 5,116,509 (*Cooper*) (UV between an RO and an electrodeionization unit).

It will be seen that the foregoing effect is neither anticipated nor taught in, and the claimed treatment is absent, from the references which are discussed above.

The remaining cited reference, Ciepiella *et al.* '908, was cited merely for the proposition that electrodialysis (ED) or ion exchange beds may replace reverse osmosis (RO) units for demineralizing a feed. However, the general use of these various units for treating sour refinery waters as described by Ciepiella *et al.* has no teachings relevant to processes for substantially entirely removing TOC, to affect UV treatment of the nonionizable and convertible-to-ionizable species as recited in Applicant's claims.

All claims are therefore believed to be allowable. Accordingly, reconsideration of the application, examination of the claims, including the previously-filed amendments, and allowance are all therefore earnestly solicited at this time.

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CONCLUSION

Entry of the amendment and allowance of all claims are now earnestly requested. If any further matter is found to require attention, the Examiner is invited to telephone the below-signed attorney in order to expeditiously address such matter.

Respectfully submitted,

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PENDING CLAIMS

1. A method for purifying water, wherein the water contains both (i) ionizable and/or ionized organic carbon compounds and (ii) non-ionized and/or non-ionizable organic carbon compounds, such method comprising the steps of:
 - (a) processing a first stream of the water with a deionization apparatus¹² to remove from the water ionized organic carbon compounds and certain organic compounds that are ionizable in said deionization apparatus, wherein at least some of such ionized and/or the certain ionizable organic carbon compounds are susceptible to conversion to non-ionized and/or non-ionizable organic carbon compounds by an agent intended for converting non-ionized and/or non-ionizable organic compounds into ionized and/or ionizable organic compounds, thereby producing a first product stream containing a smaller concentration of ionized and/or ionizable organic carbon compounds including the certain organic compounds, than the first stream;
 - (b) contacting the first product stream with said agent for converting non-ionized and/or non-ionizable organic carbon compounds into ionized and/or ionizable organic carbon compounds at a time and a temperature sufficient to form a second product stream containing a smaller concentration of non-ionized and/or non-ionizable organic carbon compounds than the first stream and a larger concentration of ionized and/or ionizable organic carbon compounds than the first product stream;
 - (c) processing the second product stream with a second deionization apparatus for removing ionized and/or ionizable organic carbon compounds from the water to form a third product stream containing a smaller concentration of ionized and/or ionizable organic carbon compounds and of non-ionized and/or non-ionizable organic carbon compounds than the first stream; and

- (d) recovering the third product stream from step (c), wherein at least one of said first deionization apparatus and said second deionization apparatus is selected from the group consisting of electrically regenerated ion exchange apparatus, electrodeionization apparatus, electrodialysis apparatus, filled cell electrodialysis apparatus and electrodiuresis apparatus.
2. A method according to claim 1 including a recirculating flow loop and wherein the first removal deionization apparatus comprises the second deionization apparatus.
3. A method according to claim 1 wherein one of said first deionization apparatus and said second deionization apparatus is selected from the group consisting of electrically regenerated ion exchange apparatus, electrodeionization apparatus, electrodialysis apparatus, filled cell electrodialysis apparatus, filled cell electrodialysis apparatus and electrodiuresis apparatus, and one of said first deionization apparatus and said second deionization apparatus is selected from the group consisting of reverse osmosis apparatus, nanofiltration apparatus, chemically regenerated ion exchange apparatus, activated carbon apparatus and other sorbent apparatus.
4. A method according to claim 1, wherein the agent is selected from the group consisting of an oxygen, ozone, singlet oxygen, hydrogen peroxide, chemical oxidizing agent, electrolytic oxidizing agent, electrochemical oxidizing agent, catalytic oxidizing agent, thermal oxidizing agent, and radiation and combinations thereof.
5. A method according to claim 4 wherein the agent comprises radiation characterized by wavelengths of about 184.9 nm.
6. A method according to claim 1 wherein the agent comprises ultraviolet radiation.
7. A method according to claim 6 wherein the agent further comprises hydrogen peroxide.

8. A method according to claim 6 wherein the agent further comprises a catalyst.
9. A method according to claim 6 wherein the agent further comprises a catalyst.
10. A method according to claim 9 wherein the catalyst comprises titanium oxide.
11. A method according to claim 1 wherein the agent comprises ozone and hydrogen peroxide.
12. An apparatus for purifying water, wherein the water contains both (i) ionizable and/or ionized organic carbon compounds and (ii) non-ionized and/or non-ionizable organic carbon compounds from water comprising:
 - (a) a deionization apparatus to remove from the water ionized organic carbon compounds and certain organic compounds that are ionizable in said deionization apparatus, wherein at least some of such ionized and/or the certain ionizable organic carbon compounds are susceptible to conversion to non-ionized and/or non-ionizable organic carbon compounds by a conversion means intended for converting non-ionized and/or non-ionizable organic carbon compounds into ionized and/or ionizable organic carbon compounds, thereby producing a first product stream containing a smaller concentration of ionized and/or ionizable organic carbon compounds including the certain organic compounds, than the first stream;
 - (b) a conversion means for converting non-ionized and/or non-ionizable organic carbon compounds into ionized and/or ionizable organic carbon compounds at a time and a temperature sufficient to form a second product stream containing a smaller concentration of non-ionized and/or non-ionizable organic carbon compounds than the first stream and a larger concentration of ionized and/or ionizable organic carbon compounds than the first product stream;

- (c) a second deionization means for removing ionized and/or ionizable carbon compounds from the water to form a third product stream containing a smaller concentration of ionized and/or ionizable organic carbon compounds and of non-ionized and/or non-ionizable organic carbon compounds than the first stream; and
 - (d) a recovery means for recovering the third product stream;
- wherein at least one of said first deionization means and said second deionization means is selected from the group consisting of electrically regenerated ion exchange apparatus, electrodeionization apparatus, electrodialysis apparatus, filled cell electrodialysis apparatus and electrodiuresis apparatus.
- 13. An apparatus according to claim 12 including a recirculating flow loop and wherein the first removal deionization apparatus comprises the second deionization apparatus.
 - 14. An apparatus according to claim 12 wherein one of said first deionization means and said second deionization means is selected from the group consisting of electrically regenerated ion exchange apparatus, electrodeionization apparatus, electrodialysis apparatus, filled cell electrodialysis apparatus and electrodiuresis apparatus and one of said first deionization means and said second deionization means is selected from the group consisting of reverse osmosis apparatus, nanofiltrative apparatus, chemically regenerated ion exchange apparatus, activated carbon apparatus and other sorbent apparatus
 - 15. An apparatus according to claim 12 wherein the conversion means comprises contact means for contacting the first product stream with an agent.
 - 16. An apparatus according to claim 15 wherein the agent is selected from the group consisting of a oxygen, ozone, singlet oxygen, hydrogen peroxide, chemical oxidizing agent, electrolytic oxidizing agent, electrochemical oxidizing agent, catalytic oxidizing agent, thermal oxidizing agent, and radiation.

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17. An apparatus according to claim 16 wherein the oxidizing agent comprises radiation characterized by wavelengths of about 184.9 nm.
18. An apparatus according to claim 16 wherein the oxidizing agent comprises ultraviolet radiation.
19. An apparatus according to claim 18 wherein the agent further comprises hydrogen peroxide.
20. An apparatus according to claim 18 wherein the agent further comprises ozone.
21. An apparatus according to claim 20 wherein the agent further comprises a catalyst.
22. An apparatus according to claim 16 wherein the catalyst comprises titanium oxide.
23. An apparatus according to claim 15 wherein the agent comprises ozone and hydrogen peroxide.